1 Introduction: Laboratory Typologies

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The term lab or laboratory is as multifaceted as its linguistic background: In Latin, “laborare” means to work, to suffer, to try. The term is used for buildings – laboratory building, rooms – chemistry laboratory, functional units – central laboratory, or virtual entities – web laboratory. Even in the restriction to rooms, there is a spectrum ranging from the chemistry laboratory to the sleep and language laboratory. Workshop and equipment rooms are not clearly separated from the laboratories – a situation apparently often misused in order not to have to meet safety requirements. In the chapter “area of application,” the laboratory guidelines “Sicheres Arbeiten in Laboratorien (Safe Working in Laboratories)” BGI/GUV-I 850-0 (Issue: March 2014) include an extensive definition of the term for “laboratories,” which also serves as the basis for the remarks to follow.

Laboratories (labs) are workrooms used by specialists or people instructed to carry out experiments for the research and usage of natural scientific processes. … Among these, we find, for instance, chemical, physical, medical, microbiological, and genetic engineering laboratories. [BGI 850].

The classification into lab groups and lab types can be performed and viewed from different angles and according to the following criteria:

• Purpose
• Type of use
• Science direction
• Field of activities
• Working methods
• Physical structure
• Requirements in Terms of Building and Safety Technology.
1.1 Purpose

Labs and lab buildings are constructed for “public users” – universities, research facilities – and “private users” – industrial firms, and service providers. The buildings are constructed in order to be used by the owner or to be rented. With regard to the conception of the lab areas, distinction can be made between a “customized” area for specific usage corresponding to a specific space allocation plan and “potential sites,” such as those in flexible general purpose buildings (Figure 1.1).

Laboratory areas can also be classified corresponding to the type of use:

- **Teaching**: practical training, teaching labs
- **Research**: basic research, applied research
- **Diagnostics/analytics**: contract laboratory, process analytics
- **Development**: pharmaceutical, lacquer, and process development.

All existing laboratory areas can be classified by means of these four groups. There are enormous differences regarding the surface areas required, the technical and mechanical equipment, and the occupancy rate, which makes qualitative and quantitative comparison of the areas impossible. Even a seemingly clear and distinct group, such as the group of practical training labs, differs hugely in terms of equipment and requirements, as can be seen in Figures 1.2 – 1.6. The separations within the groups are also not clear and distinct; this is because teaching can also take place in the research laboratory and research, in turn, can take place in the development laboratory. Independent areas of analytics are often implemented as a type of service in research and development departments.

![Figure 1.1 Purpose of the building.](image-url)
1.2 Science Direction

It is obvious to group the lab areas or lab buildings corresponding to the basic science areas:

- Chemistry
- Biology
- Physics.
We find overlapping even when taking a two-dimensional look at the core disciplines, and they cannot, thus, be allocated clearly to one specific group (Figure 1.7). A broader grouping by science area and application, such as pharmaceutics, medicine, or engineering, will make the problem even bigger because some type of overlapping also exists for these fields.

1.3 Fields of Activities

Classification of the laboratories can be performed corresponding to the activities carried out in the laboratory.
1.3 Fields of Activities

Figure 1.6 Practical training anatomy.

Figure 1.7 Biochemistry: biology or chemistry?

- Synthesis/preparation laboratory
- Analytics/measurement laboratory
- Process engineering.

Something is either

- produced, synthesized, prepared, or cultivated
- characterized, analyzed, or measured
- developed: Measurement methods or production processes.

Synthesis laboratories are engaged with the characterization and measurement of the substances, whereas most analytics laboratories are engaged with the preparation of samples and the development of measurement methods. Now, the
question is whether these activities take place in the same room or in separate areas.

1.4  
**Working Methods**

Grouping in the laboratory can be performed depending on the respective working methods:
- Working at the laboratory bench with small-sized devices
- Machine- or major device-oriented working
- Process-oriented working.

1.5  
**Physical Structure**

Classification of labs into types can be carried out according to physical structures:
- Single laboratory
- Double laboratory
- Open-plan laboratory
- Combination laboratory/laboratory landscape
  - Files for physical structures.

The combining of the classifications results in an allocation structure with clear and distinct specifications, as can be seen in the example of a synthesis laboratory (Figure 1.8).

1.5.1  
**What is the Conclusion Resulting from the Evaluation of the Lab Allocation Tree?**

A double laboratory in a public research institute typically consists of four to six workplaces. As a minimum, one chemical hood is required per staff member in a chemistry synthesis lab. Synthesis lab, organic chemistry or inorganic chemistry? Inorganic, organometallic, or solid-state chemistry? In some cases, solid state chemistry means synthesis isolators (Figure 1.9).

Decision criteria for the design concept are provided by each level. These criteria consciously or unconsciously flow into the planning process. However, the basic conditions for the building and the detailed information for the lab room have not yet been provided. The example shows that the air quantities required differ by a factor of 3.

Good laboratory buildings result from the inside, through an internal interactive process, and from the outside, through an interdisciplinary planning team. To a smaller extent, this requires types of laboratories and standard laboratories, but to a larger extent, this requires use-specific and building-related needs and requirements.
1.5.2 Use-Specific and Building-Related Needs and Requirements

The determination of requirements for the use-specific and building-related needs and requirements does not primarily refer to rooms, but to workplaces and working areas. In an initial step, it is essential to define the special buildings or special components required which result from the intended use or the safety
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Figure 1.9  Inorganic synthesis lab (a) and synthesis isolators (b).

requirements. The second step concerns the characterizing of those special areas in the lab building which result from operator, object, or product protection. In order to find the technical system of the building concept, the basic conditions for the air quantities and the media equipment are determined in a final step.

1.5.3 Determination of the Areas for Independent Buildings or Special Components

Legal stipulations or building typologies of completely different types result in laboratory areas which should be implemented in the form of an independent building or part of a building.

- Safety laboratories with protection level BSL4 genetic engineering
- Handling of explosives
- High-pressure synthesis
- Ceiling height used > 3.5 m
- Keeping of animals
- Clean rooms
- High-accelerating electrical fields, for example, NMR
- Sensitive to EMC and oscillation

1.5.4 Determination of the Areas as Restricted Areas

The laboratory areas are not accessible to any third parties at any time. This refers to the restricted access for lab staff members within a laboratory area, that is, only designated lab staff members have access to the locked area.

1.5.5 Areas with Locks and Access Area

- Safety areas BSL3 genetic engineering, biomaterial regulation
- Isotope areas at protection level 1
• Product protection or prevention of cross-contamination
• Handling of active or highly-active substances (Amount > mg)
• Safety area BSL 2 genetic engineering, biomaterial regulation
• Laser areas and exposure to radiation
• Handling of highly-toxic substances (Amount > xg).

1.5.6
**Determination of Areas with Special Requirements Regarding Fire and Explosion Protection**

Labs for endurance tests and kilo labs dealing with solvents of more than 2.5 l are typical rooms with special requirements regarding fire and explosion protection. These areas are either separated from the laboratory area or implemented within the laboratory area in a separated form.

1.5.7
**Determination of Areas for the Laboratory Equipment**

Lab equipment rooms with high thermal load and noise level, which are only operated for a short time, dark rooms, and storage rooms are allocated to the lab areas and implemented without daylight.

1.5.8
**Determination of Areas for Special Laboratories**

These are lab areas with daylight for joint use, for example, cell culture or for special equipment, such as a mass spectrometer. The areas for special laboratories are either integrated into the lab area or realized in the form of an autarkic zone.

1.5.9
**Determination of Standard Laboratory Areas**

The project-specific standard lab areas are formed by combining all lab workstations into one lab area. Standard lab areas may either consist of several standards or, in some areas, can be formed differently in a project. The development of standard lab areas, with validity for the entire project or only in some areas, creates the flexibility required for standard jobs. Evaluation and documentation working places have either been integrated into the standard laboratory areas or have been allocated directly. The special lab areas and the lab infrastructure areas result in laboratory areas in the form of usage units.

1.5.10
**Conception Laboratory Building**

The grouping of those lab areas with technological safety and building requirements is the basis for the conception of the laboratory building (Figure 1.10);
administrative areas and further functions, as well as communication and interaction in the future building are to be taken into account.

1.6
Conclusion

Laboratories for natural science mirror nature – they are apparently indefinitely complex and simply organized in detail. There are appreciable differences between the laboratories, and yet, they are just the sum of simply structured individual workplaces:

- Laboratory bench workplace
- Laboratory bench equipment workplace
- Chemistry workplace with chemical hood and hazardous substance storage
- Workplace with product and operator protection – Safety workbench
- Equipment workplace with flexible supply
- Supply workplace with storage cabinet and cooled storage rooms
- Evaluation and documentation workplace.

Project-specific individual laboratory areas are created by combining these workplaces; in the spirit of Aristotle (384–322 BC) “The whole is more than the sum of its parts.”

Often, the planning of rooms and laboratory types is nothing but looking back at existing areas. New laboratory buildings are not supposed to be a copy of the existing buildings. It is better to learn from the existing buildings and the experiences made in order to develop new and sustainable laboratory areas in the future.